Thermal Design of the Cassini Narrow Angle Camera

Pamela Hoffman
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, California 91109

Abstract

The arrow Angle Camera (NAC) is one of two cameras in the Imaging Science Subsystem (ISS) on the Cassini Spacecraft (S/C), the second camera is a Voyager-inherited Wide Angle Camera (WAC). Cassini is currently planned to be launched in October 1997 and will arrive at Saturn for a four year tour in June 2004. The Narrow Angle Optics arc a Ritchey Chretien type Optics, has a focal length of 2000 mm, a relative aperture of f/ 10.5, a spectral range of 200 to 1100 nm, 24 filters, a pixel field of view of 6.0 n~icmradian/pixel, and has a field of view of 3.5 x 3.5 degrees. 'l"he sensor is a Charged Couple Device (CCD), 1024 x 1024 pixels with a pixel size of 12 x 12 um, a full well greater than 50,000 e-, on chip processing of up to 800,000 e- pixel summation, a dark current of less than O. 1 e-/pixcl/sez at operating temperature, and a charge transfer efficiency of 0.99999 at operating temperat ure.

The NAC, along with the WAC and several other Remote Sensing Instruments, is located on the Remote Sensing Pallet (RSP) which is hard mounted to the S/C. The Allowable Flight Temperature (AFT) limits for the NAC arc -20°C to +30°C non-operating and - 10°C to +25°C operating. Under operating conditions, the NAC Optics has a 2*C gradient requirement between the Primary and Secondary Mirrors and along the Invar metering rods. For each mirror, the maximum gradient allowed under operating conditions is 1 °C radiall y. The CCD AFT limits arc - 12(PC to +50°C non-operating and -93°C to -87°C operating. The RSP temperature requirements at the NAC/RSP interface arc the same as the NAC AFT limits.

The NAC is thermally coupled to the. RSI' both radiatively and conductively. The aperture has no cover or close-out lens thus allowing both mirrors and the optics barrel to radiate directly to space. The CCD is cooled passively with a cold finger anti radiator system. With the exception of the radiator and aperture, the camera and local RSP interface is blanketed with Multi-] ayer insulation (MLI). One thermal and 10 geometric math models thermally characterize the NAC. The 1 O geometric math models represent various regions of the camera and surrounding environment and provide all of the radiation conductors for the thermal math model. The thermal math model consists of 228 nodes and includes the entire NAC (hood, primary and secondary mirrors, metering rods, optics barrel, fi lter whet], shut tcr, sensor head elect ronics, CCD, coldfinger, radiator, Ml J, RSP interface, and external surroundings).

Due to S/C and 1SS power constraints, only 7.5W peak power is available for electrical heater power to maintain AFT operating limits and gradient requirements. Six of the 7.5W must be power shared with the filter wheel. The CCD uses a 1.5W proportional control heater to

maintain the -90°C ± 3°C operating temperature limit. The remaining 6W, which is power shared with 'the filter wheel, is used at the primary and secondary mirrors to maintain both AFT operating limits as well as to maintain the 2°C gradient requirement. Under worst-case filter movement operat ing scenarios, the average power available for the optics heaters is 5. 6W. Under hot conditions, in a worst-case thermal analysis, all 5.6W of average heater power is required at the secondary mirror to meet the 2°C gradient requirement. Under cold conditions, in a worst-case thermal analysis, 3.3W of average heater power is required at the secondary mirror to meet the 2°C gradient requirement and 2.7W is required at the primary mirror to maintain the - 10*C lower AFT operating limit. In order to meet all of the operating temperature requirements under both cold and hot operating conditions, to stay within the power constraints, and to insure satisfactory optics performance, the optics heaters utilize a closed loop control algorithm that includes pulse-width modulation.

The worst-case analysis has been completed. In January 1994, a thermal development test of the NAC will be performed. The models used for the worst-case analysis will be updated and correlated with the test results, Based upon the test results and correlated models, the final NAC thermal design will be defined. The paper to be presented will discuss the worst-case, analysis in far more detail, the closed-loop control algorithm, and the test results. The paper will also discuss potential ways to resolve thermal problems that may arise during the test.